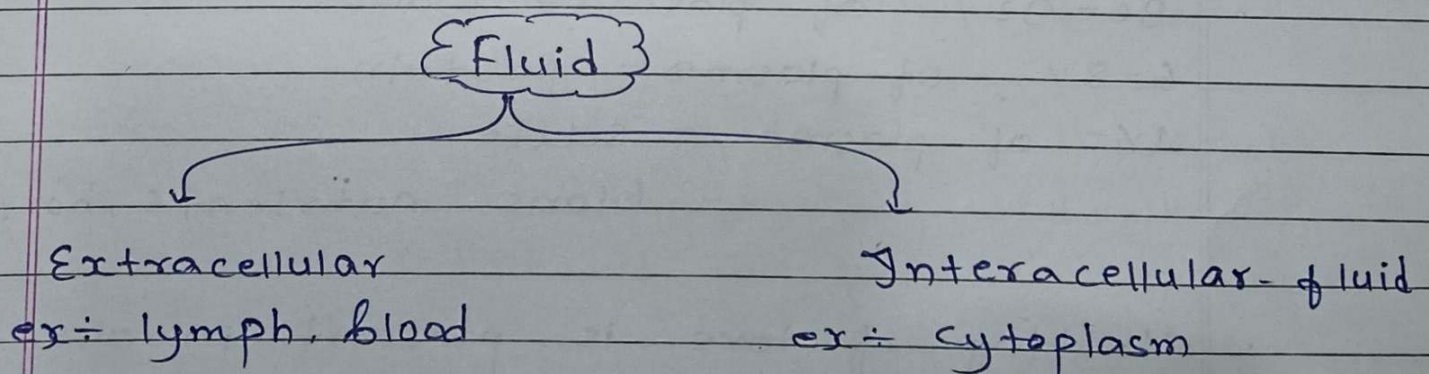


Body Fluids and Circulation

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* Introduction

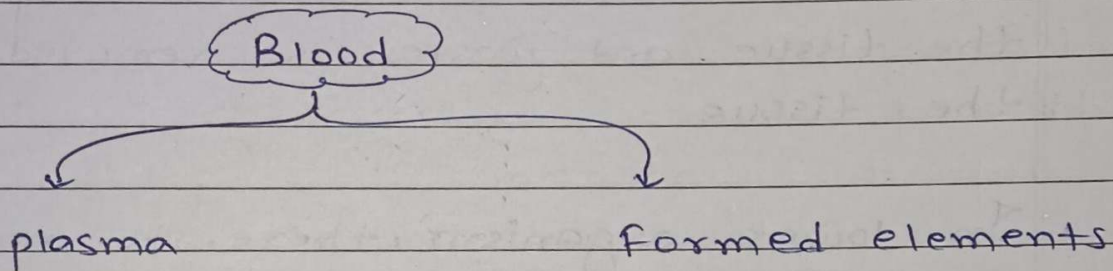
- In our body, essential substance is supplied to the cells and waste products are removed from the cells. For this, blood vascular system is present in our body.
- Blood is the carrier in which essential substance are loaded and supplied to the tissue and waste is removed from the tissue.
- In lower organism there is no special fluid. They use water from their surrounding to transport material in their body.
ex: sponges, coelenterata.
- Higher animal have special fluid to transport material in their body.
ex: lymph, blood



Note:- Blood is the main circulating fluid in our body.

* Blood

- Special connective tissue
- Fluid in nature
- Healthy man = 5-6L
- Healthy women = 4-5L
- Mesodermal origin



* plasma

- liquid matrix
- 55% of blood
- Straw colour/pale yellow
- Viscous fluid

* Composition of plasma

- 90-92% of plasma = water
- 6-8% of plasma = protein
- 1% of plasma = solute
(ions, nutrients, hormone)

- Clotting factors is present in our body in inactive form.

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Serum = plasma - protein

* Function of protein found in plasma

(1) Albumin

↳ Maintain osmotic balance

↳ Smallest protein

(2) Fibrinogen

(3) prothrombin } blood clotting

(4) Globulin

↳ α globulin } transport of material
↳ β globulin }
↳ γ globulin → immunity / defense mechanism

* Formed elements

• 45% of blood

• Cellular component

(i) RBC (ii) platelets (iii) WBC

* RBC or Red blood cell or erythrocyte

• Count = 5 - 5.5 million per mm^3 of blood

• lifespan = 120 days

• Form in red bone marrow in adult

• In embryo, RBC is formed initially in yolk sac, later it is produced in liver and spleen

- Spleen is graveyard of RBC
- Biconcave shape of RBC in most mammal (except - camel and lama)
- Due to presence of red color pigment called haemoglobin, RBC is red in color.
- Immature RBC is nucleated, but during maturation, nucleus and other membrane bound organelles are removed from RBC so that more space is available for accommodation of haemoglobin, hence mature RBC is enucleated.
- 12-16gm of Hb is present in 100ml of blood

* platelets or thrombocyte

- count = 1.5 - 3.5 lakh per mm^3 of blood
- formed in red bone marrow
- enucleated
- Formed by fragmentation of megakaryocyte
- Help in clotting of blood

- * WBC or White blood cell or leucocyte
- Count: 6000-8000 per mm^3 of blood
- Average life span is short (7 days)
- Formed in red bone marrow
- White in colour (no haemoglobin)

WBC

granulocyte

- have granules like structure in cytoplasm

agranulocyte

- granules like structure absent in cytoplasm

- * Granulocyte
- three types

(1) Neutrophil

- 60-65% of WBC
- phagocytic cell
- most abundant WBC
- also known as PMNL

PMNL

↳ poly morpho nucleated leucocyte

(2) Eosinophil

- 2-3% of WBC
- it resist infection or parasitic infection
- also play role in allergies
- headphone shaped nucleus

(3) Basophil

- 0.5% of WBC
- least abundant WBC
- involves in inflammatory reaction
- release :
 - (i) histamine (vasodilator)
 - (ii) Serotonin (vasoconstrictor)
 - (iii) Heparin (natural anticoagulant)

* Agranulocyte

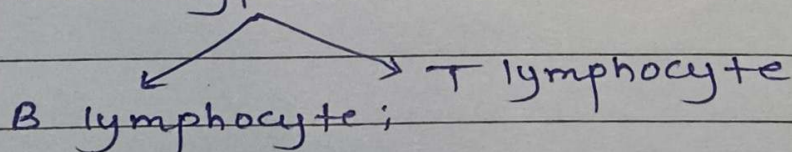
two types

(1) Monocyte

- Kidney shaped nucleus
- phagocytic cell
- 6-8% of WBC

(2) Lymphocyte

- 20-25% of WBC
- two types



- lymphocyte provide immunity

* Blood group

- There are many types of blood group system all over the world
- We use two types of blood group system
 - (i) ABO blood group system
 - (ii) Rh blood group system

Note:- Blood group antigen is chemical present on surface of RBC.

- Antibody is protein that is present in plasma of blood.

* ABO blood group system

- Two types of antigen
 - (i) A antigen
 - (ii) B antigen
- Two types of natural antibodies
 - (i) Anti-A antibody
 - (ii) Anti-B antibody
- Same antigen + same antibody = clumping / destruction of RBC.

- A person do not have same type of antigen and antibody
- For safe blood transfusion, blood group is always matched before transfusion.

Blood group	Antigen	Antibody	Donor's gr
A	A	anti B	A, O
B	B	anti A	B, O
AB	A, B	nil	A, B, AB, O
O	nil	anti-A, anti-B	O

* Rh blood group system

- Rh stands for rhesus monkey
- Rh ag present = Rh +ve
- Rh ag absent = Rh -ve

Rh is dominant character = RR }
 Rr } $\rightarrow$ Rh +ve
 rr $\rightarrow$ Rh -ve

- 80% people of world is Rh +ve
- 97% people of India is Rh -ve

Universal donor $\rightarrow$ O - ve

Universal recipient $\rightarrow$ AB +ve

* Erythroblastosis foetalis

- In Rh incompatibility case
 mother = Rh -ve
 father = Rh +ve
 Child will be Rh +ve

- During 1st pregnancy
- Mother and foetus well separated by placenta
- Nutrition, O_2 , other essential substance is provide to foetus from mother through umbilical cord.
- During delivery of 1st child, foetus and mother blood get mixed due to breaking of placenta and cutting of umbilical cord
- Due to mixing of blood, mother forms anti Rh antibody in her body (against Rh antigen of fetus)

- During 2nd pregnancy
- Again, child is Rh +ve and mother is Rh -ve
- This time mother will supply nutrients as well as anti-Rh antibody to the foetus
- This time anti-Rh antibody will destroy foetal RBC causing death or severe anemia or jaundice to the foetus
- Correction method
This cause can be corrected by supplying readymade anti rh antibody to the mother immediately after delivery of 1st child
ex: Rhogan (anti Rh antibody)

* Erythroblastosis foetalis
 ↳ RBC ↳ damage or clumping ↳ foetus

* Clotting of blood

- To prevent excess blood loss from the body, blood has a property of clotting or coagulation.
- When an injury occurs, blood loss continues for sometime but after sometimes a reddish brown scum is formed at the site of injury.

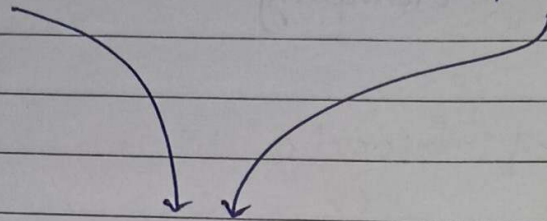
* Anti-clotting

- Chemical that prevent clotting of blood
- Natural anticoagulant found in our body is heparin.
- Artificial anticoagulant used in labs are sodium citrate, sodium oxalate, EDTA
 ↳ ethylene diamine tetra acetic acid

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* Mechanism of clotting

Injured tissue platelets



release factors like
thromboplastin



thrombokinese complex



prothrombin (inactive) → Thrombin (active)



Fibrinogen (inactive, soluble) → Fibrin (active, insoluble)

- Fibrin form network in which dead formed elements trap at the site of injury. This is known as clot/scum/coagulum.

- Ca^{2+} ions and vitamin K play very important role in clotting of blood

- Anticoagulant works by chelating Ca^{2+} ions

* Lymph

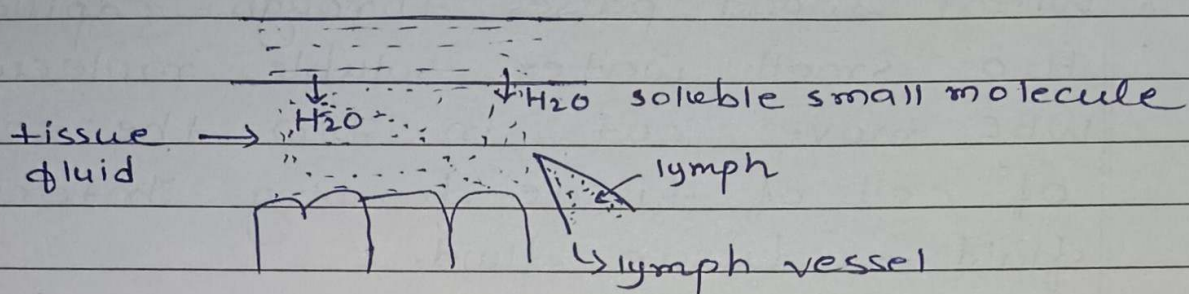
- colourless fluid
- When blood passes through capillaries H_2O , small water soluble molecules, WBC moves out in b/w the space of cell of tissue forming interstitial fluid or tissue fluid.
- Tissue fluid has same mineral distribution as that of plasma
- When tissue fluid enters in lymphatic vessel, it is called as lymph.
- Lymphatic system consists of :-
(a) lymph (b) lymphatic vessel (c) lymph nodes

* Function of lymph

- (i) It acts as a middle man. Helps in exchange of substances, such as nutrients, hormones etc b/w blood and tissue.
- (ii) It is a carrier of many substances (nutrients, hormones etc)

(iii) It is involved in immune response

(iv) Absorption of fat from intestinal villi through lacteals.



* Circulatory system

There are two types of circulatory system

- (1) Open circulatory system
- (2) Closed circulatory system

* Open circulatory system

- Blood vessels are poorly developed
- Heart pumps blood in large vessel which open in body cavity known as sinus.

ex: Arthropods, mollusc

* Closed blood circulatory system

- Blood vessels are properly developed
- Heart pumps blood in network of vessels
- More advantageous than open circulatory system

ex: annelid, chordat

* Types of heart in different vertebrate

- Vertebrates have muscular and chambered heart
- upper chamber - Atria/Auricle (receive blood)
- lower chamber - Ventricle (pumps blood)

(1) Heart of fish

- 2 chambered heart; 1 atrium, 1 ventricle
- Venous heart because it pumps deO₂ blood
- Single circulation

(2) Heart of Amphibia and reptile

- 3 chambered heart; 2 atria, 1 ventricle
- pumps mixed blood
- Incomplete double circulation

Note: Crocodilia is an exception. It has 4 chambered heart.

- In Reptiles, division b/w ventricle starts forming, but it is not completed, mixing of blood is still there

(3) Heart of mammals and birds

- 4 chambered heart: 2 atria, 2 ventricle
- pumps oxygenated blood
- Complete double circulation

* Human circulatory system

- Human circulatory system consist of :-
Heart, blood vessels and blood.

* Human heart

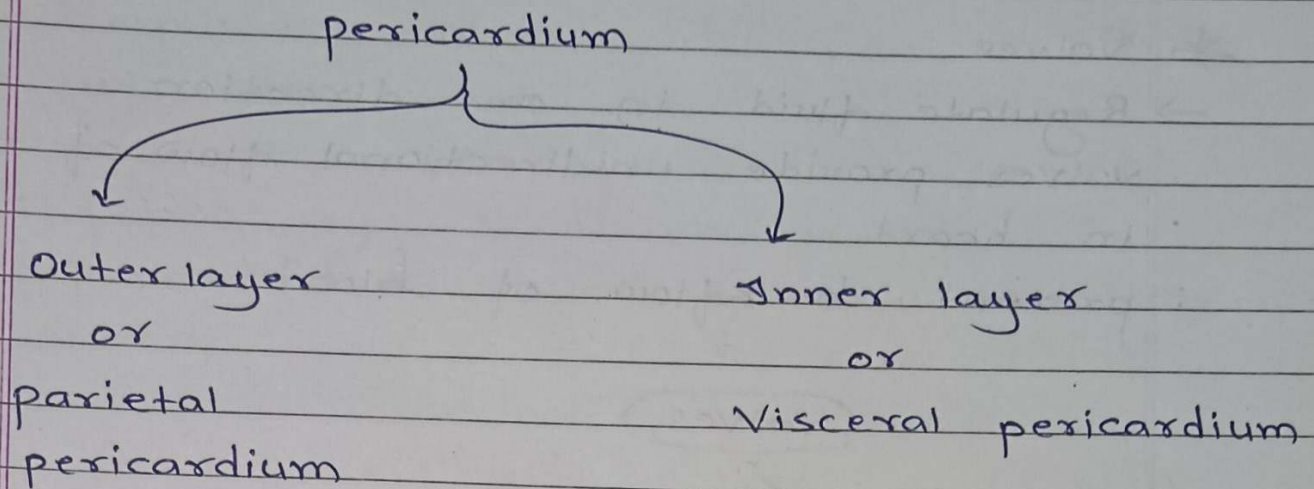
- Mesodermal in origin
- Size is clenched fist
- In thoracic cavity, b/w lungs (area :- mediastinum)
- Triangular in shape (broad base, narrower)

• Muscular are 4 chambered

+ two upper chambers (atria)

+ two lower large chambers (ventricle)

- Heart is covered by double membrane bag called pericardium

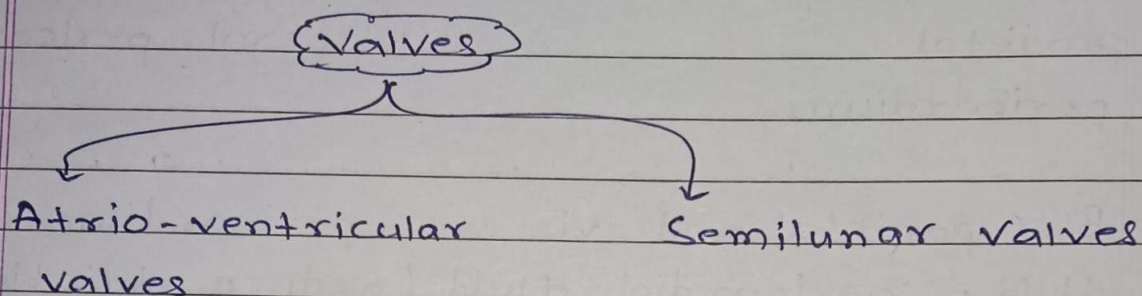


- B/w parietal and visceral pericardium is a fluid $\rightarrow$ pericardial fluid (reduce friction)
- Heart is composed of three layers
 - (a) Epicardium (outermost)
 - (b) Myocardium (middle, thick, smooth)
 - (c) Endocardium (innermost)
- Septum (dividing wall) found in three places in heart.
 - (1) B/w right ~~ax~~ atrium and left atrium
 $\rightarrow$ Inter atrial septum (thin)
 - (2) B/w right and left ventricle
 $\rightarrow$ Inter-ventricular septum (thick)
 - (3) B/w atria and ventricle of same side
 $\rightarrow$ Atrio-ventricular septum (thick and fibrous)

* Valves

→ Regulate fluid in one direction

- valves provide unidirectional flow of blood in heart.
- prevent backflow of blood.

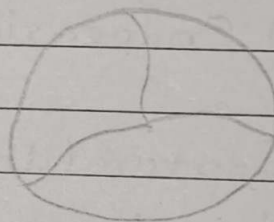


• Atrio-ventricular valves

- B/w atria and ventricle of same side
- 2 types

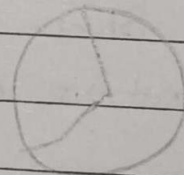
(1) Tricuspid valve

- made of three cusp
- B/w right atria and right ventricle



(2) Bicuspid/Mitral valve

- Made of 2 cups
- B/w left atria and left ventricle



- Semilunar valves

→ two types

(1) pulmonary semilunar valves

→ present b/w right ventricle and pulmonary artery

(2) Aortic semilunar valves

→ present b/w left ventricle and aorta.

* Chamber of heart

(1) Right atrium

→ Receive deO₂ blood from :-

- (a) Inferior venacava
- (b) Superior venacava
- (c) Coronary sinus

(2) Right ventricle

→ Receive deO₂ blood from right atrium through tricuspid valve

→ Give deO₂ blood to lungs through pulmonary artery

(3) Left atrium

→ Receive O₂ blood from lungs through pulmonary vein (4 in number)

(4) Left ventricle

- Receive O_2 blood from left atrium through bicuspid/mitral valve
- Give O_2 blood to aorta through aortic semilunar valve

Note:

- papillary muscle → walls of ventricle
- Chordae tendinae
 - collagenous fibres that connect papillary muscle and valves
 - prevent opening of valves on opposite side

* Double circulation

- for pumping of blood to the body, blood enters in heart twice, this is known as double circulation.
- O_2 and deO_2 blood is well separated

2 pathway

pulmonary pathway

systemic pathway

Right ventricle

↓ pulmonary artery

lungs

↓ pulmonary vein

left ventricle

Left ventricle

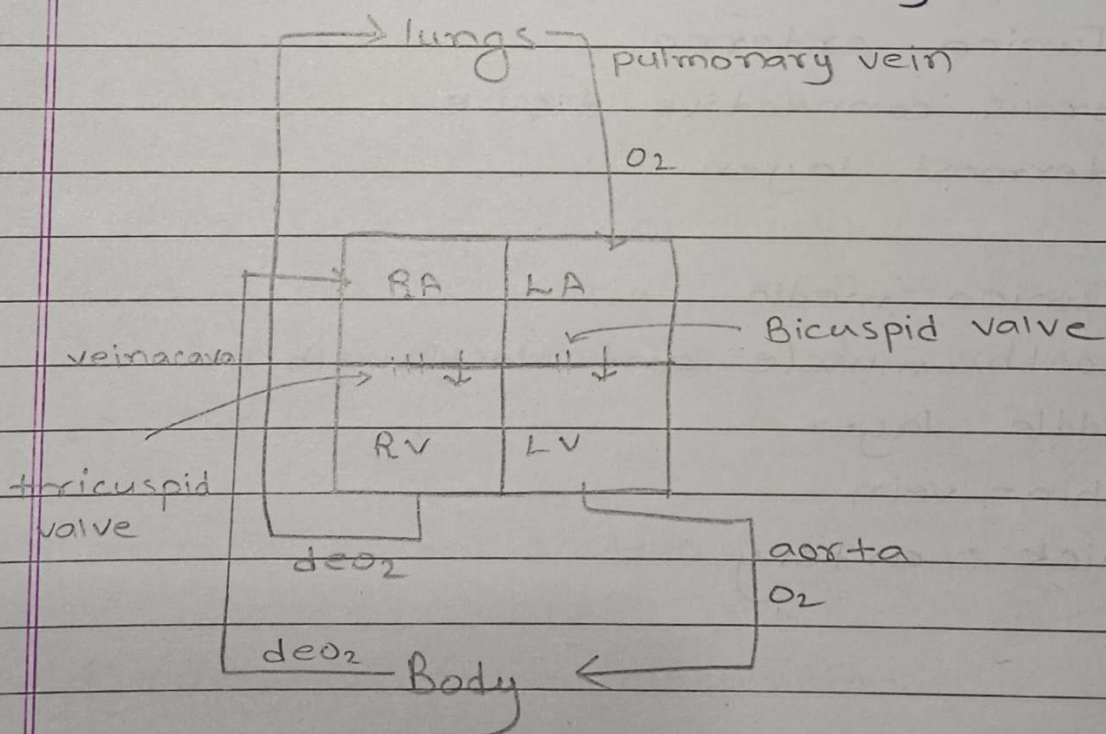
↓

body

↓

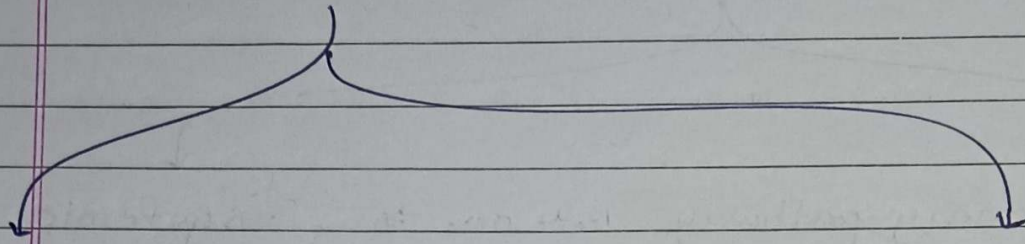
right atria

- pulmonary pathway provide deO₂ blood to lungs for oxygenation
- Systemic pathway provide oxygenated blood, nutrients etc to the body



Double circulation

* Blood vessels (two types)



Artery

→ carry blood away from heart

→ mostly carry oxygenated blood

exception = pulmonary artery

Vein

→ carry blood toward the heart

→ mostly carry deo₂ blood

exception = pulmonary vein

* Layer of blood vessels

→ three types

(1) Tunica externa

→ fibrous connective tissue

→ outermost layer

(2) Tunica media

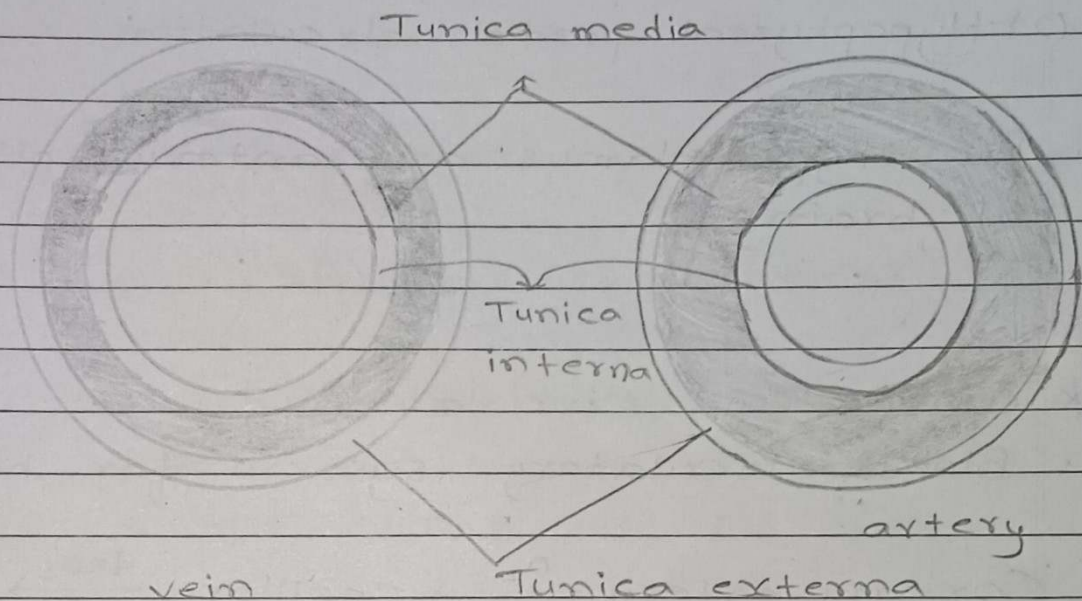
→ smooth muscle and elastic fibre

→ middle layer

→ thin = vein

thick = artery

- (3) Tunica interna/intima
→ Squamous endothelium
→ innermost layer



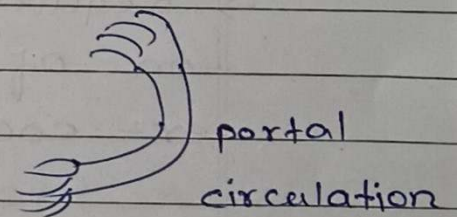
Tunica media: thin
lumen size is large

Tunica media: Thick
lumen less

* portal circulation

- Special venous connection
- Start from capillary, end to capillary
- In our body, two portal circulation is present

(1) Hepatic portal system



(2) Hypophyseal portal circulation

(1) Hepatic portal circulation

- B/w small intestine and liver

(2) Hypophyseal portal circulation

- B/w hypothalamus and anterior pituitary of brain.

* Coronary circulation

- Blood circulatory system for heart

Coronary artery $\xrightarrow{O_2}$ capillary $\xrightarrow{deO_2}$
 $\downarrow \quad \uparrow$
 $O_2 \quad CO_2$ (cardiac muscle)

coronary vein $\xrightarrow{deO_2}$ coronary sinus
 (open into right atrium)

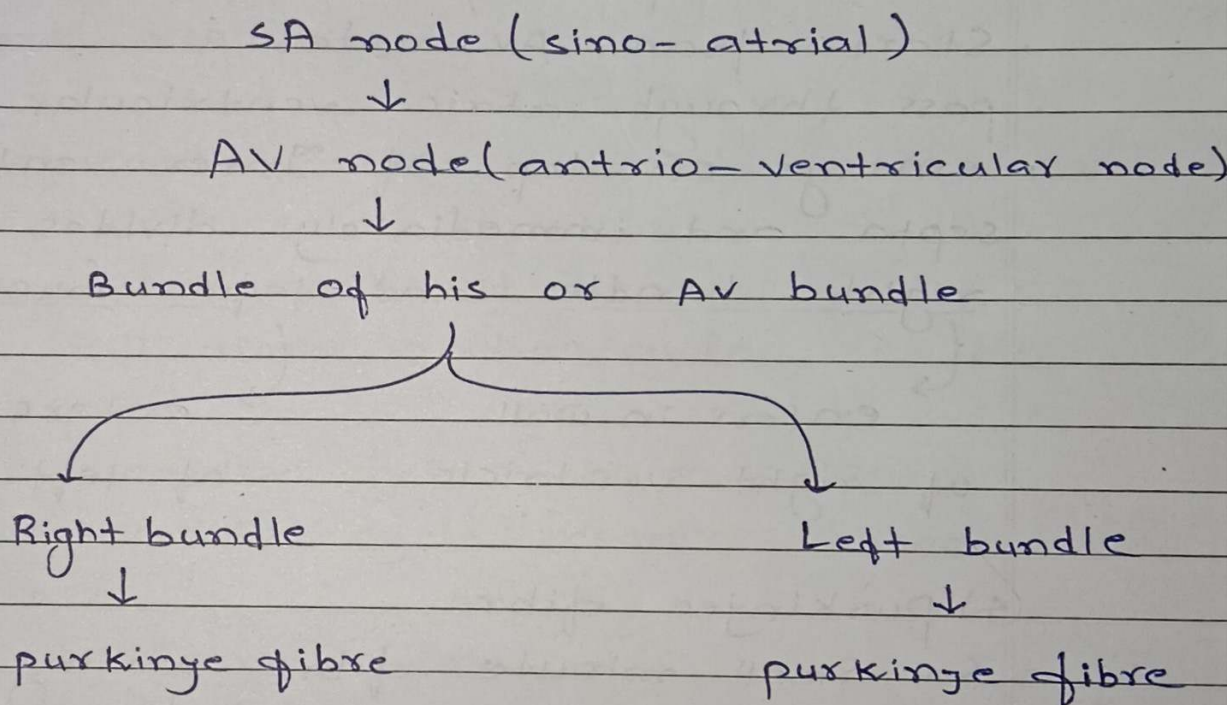
* Neurogenic heart & Myogenic ^{heart} ~~heart~~

• Neurogenic heart

- Require signal from brain for contraction of heart
- ex: cockroach

- Myogenic heart
- have auto excitable tissue
- heart contract by itself
- ex: Human

* Conduction system of heart



(1) SA node

- sino-atrial node
- right upper corner of right atrium
- generate action potential (70-75 times)
- pacemaker
 - because it initiate and maintain contractile activity of heart

(2) AV node

- Atrio-ventricle node
- lower left corner of right atrium
- pacesetter
- It receive signal from SA node through inter-nodal pathway.

(3) Bundle of his/AV bundle

- Starts from AV node
- pass through atrio ventricular septa
- emerge on top of Inter ventricular septa and immediately divides into right bundle and left bundle
 - ↳ enters in wall of right ventricle
 - ↳ enters in wall of left ventricle

(4) Purkinjee fibre

- SA Small minute fibre arising from right and left bundle in walls of ventricle
- SA node generate impulse → Both atria will contract simultaneously.
- When action potential reaches purkinjee fibres → Both ventricle contract simultaneously

- Articular pacemaker act as SA nodes
- Our heart contract 72 times/minute (average)

* Cardiac cycle

- Sequence of events taking place in our heart regularly.
- No. of cardiac cycle = No. of heart beat.

$$\begin{aligned} 1 \text{ min} &= 72 \text{ times heart beat} \\ &= 72 \text{ times cardiac cycle} \end{aligned}$$

for one cardiac cycle = $60/72 = 0.8 \text{ sec}$
So, one cardiac cycle require 0.8 sec

Systole $\rightarrow$ Contraction

Diastole $\rightarrow$ Relaxation

* Steps of cardiac cycle

There are three types steps of cardiac cycle

- (1) joint diastole
- (2) Atrial systole
- (3) Ventricular systole

(1) Joint diastole

- All 4 chambers (2 atria + 2 ventricle) are in relaxed state
- no contraction
- 0.4 sec
- During joint diastole, AV valves open. passive filling of ventricle (70%) is taking place

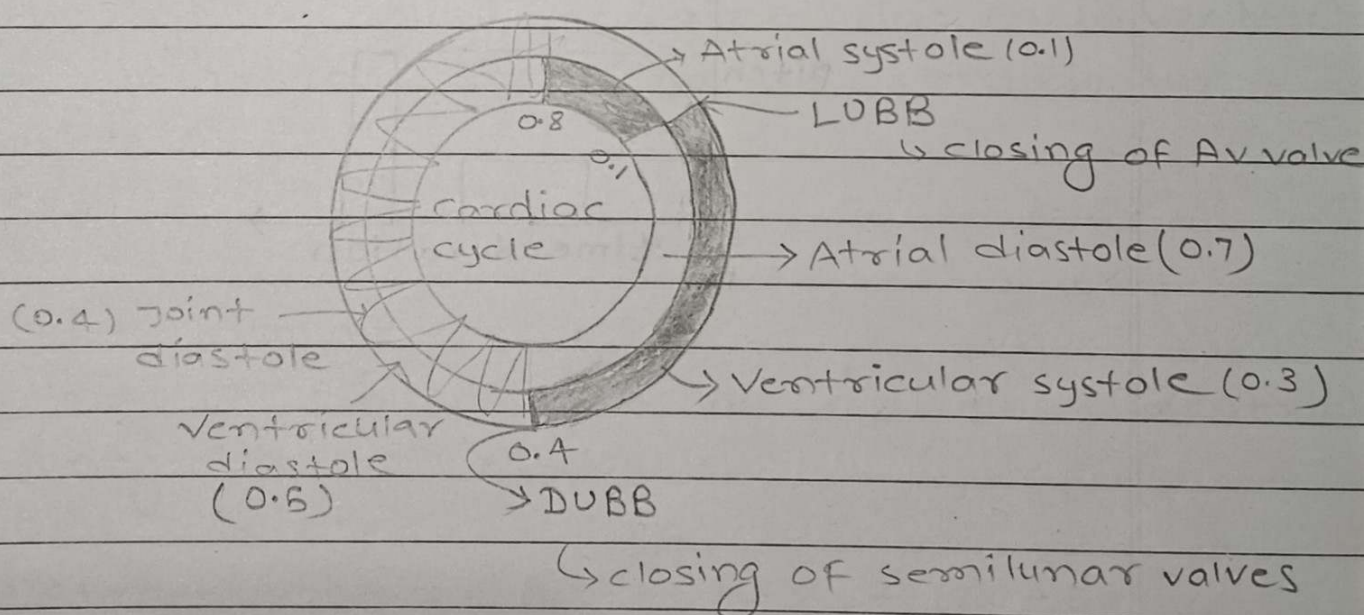
(2) Atrial systole

- Both atrial contracts simultaneously during atrial systole
- for 0.1 sec
- Both ventricle relax during this phase
- During this phase, active filling of ventricle (30%) done

(3) Ventricular systole

- ~~Form~~ from SAN, impulse reaches to purkinjee fibre through different nodal tissue and stimulation of purkinjee fibre cause ventricular contraction.
- for 0.3 sec
- During this phase atria will relax

- Pressure inside ventricle increases which cause closing of AV node valves and opening of semilunar valves.
- Blood from ventricle will flow in vessels (pulmonary artery or aorta)
- As pressure inside ventricle decline, semilunar valves will close.
- Venacava, pulmonary vein release blood in atria causing rise in pressure in atria. As a result AV valve open and passive filling of ventricle start.



* Sound produce during cardiac cycle

- Two ^{major} sounds produce during cardiac cycle

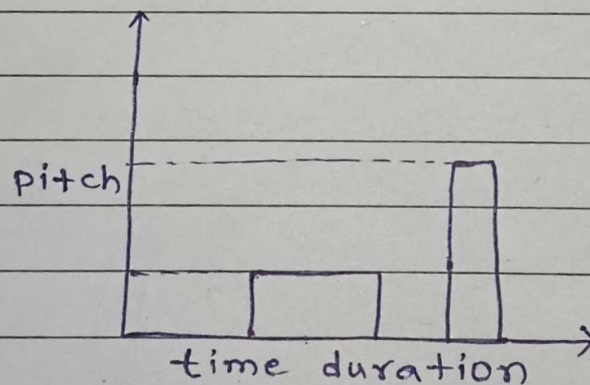
LUBB

- closing of Av valves (bicuspid & tricuspid)
- long duration
- low pitch

DUBB

- closing of semilunar valves
- high pitch
- short time duration

- Time duration b/w lubb and dubb = 0.3 sec
- Time duration b/w dubb and lubb = 0.5 sec



* Ventricle filling

passive
(70%)

- during joint diastole
- No contraction

Active
(30%)

- Atrial systole
- Atria contract

* End Diastolic volume

- Amount of blood accumulated in each ventricle at the end of Ventricular diastole.
- 120ml

* End Systolic volume

- Amount of blood remained in each ventricle of heart at the end of ventricular systole
- 50ml

* Stroke volume

- volume of blood pumped by each ventricle during a cardiac cycle.
- 70ml
- $\text{Stroke volume} = \text{EDV} - \text{ESV} = 120 - 50 = 70\text{ml}$

* Cardiac Output

- Volume of blood pumped by each ventricle in one minute

*

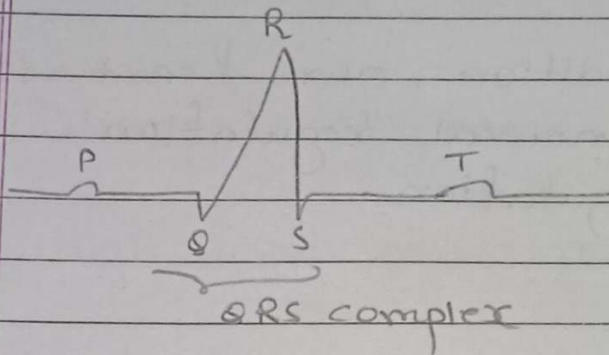
- Cardiac ~~out~~ output = no. of heart beat per minute $\times$ stroke volume

$$= 72 \times 70 \text{ mL} = 5040 \text{ mL or } 5 \text{ L}$$

* ECG (electrocardiograph)

- Electrocardiograph is a ~~mecha~~ machine to measure electric activity of heart
- Graphical representation obtained by electrocardiograph is known as electrocardio-gram
- 3 electric nodes are connected to the patient (one to each wrist, one to left ankle)
- For detail analysis, lymph nodes are connected to patient's chest region
- Deviation from standard ECG shows abnormality or disease of heart

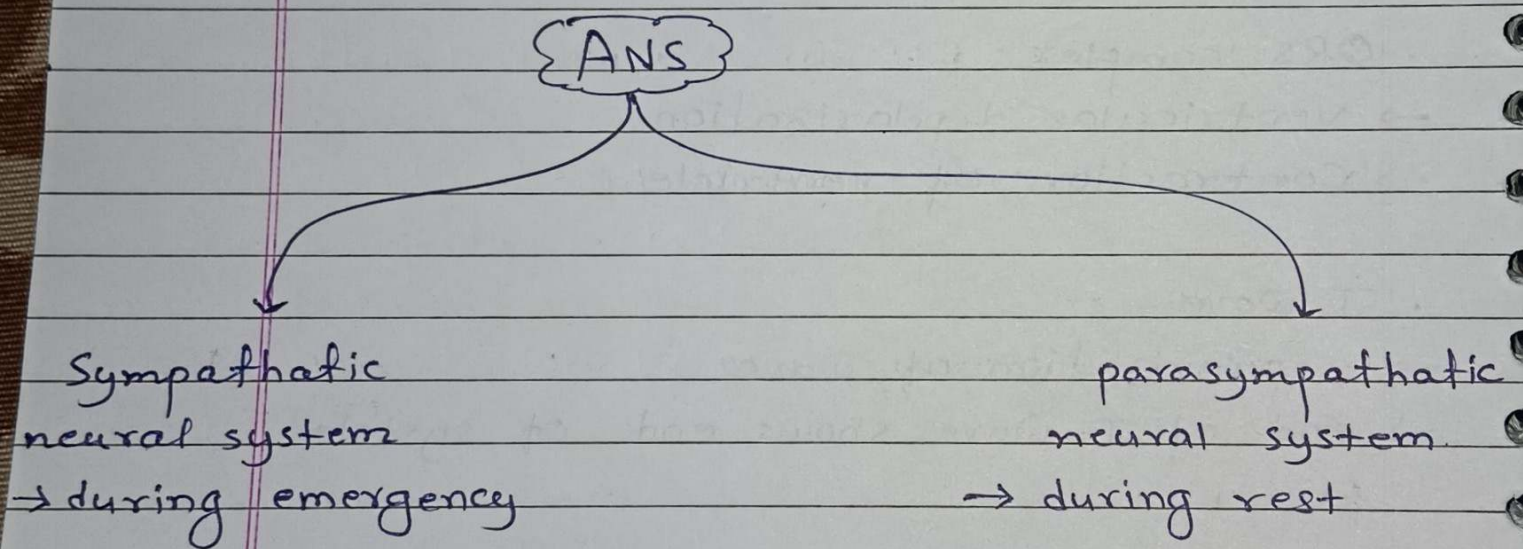
- p to T waves are observed in ECG
- ECG is of great clinical significance



- p wave
 - depolarization of atria
 - Atria contract
- QRS complex
 - Ventricular depolarization
 - Contraction of ventricle
- T wave
 - repolarization of wave
 - end of T-wave shows end of systole

* Regulation of heart

- Our heart is ~~ate~~ auto-regulated (myogenic) during normal condition.
- On certain condition, our heart is regulated by: (i) neural regulation
(ii) chemical regulation.
- Neural regulation
 - Hind brain have ~~mett~~ medulla oblongata
 - ANS (autonomic nervous system) arise from medulla oblongata



• heart beat rate ↑
• strength of ventricle ↑
• contraction
• Cardiac output ↑

• heart beat rate ↓
• Cardiac output ↓
• Conduction of ↓
• signal in heart

- Chemical regulation
→ includes hormones
ex: emergency hormone (epinephrin + non-epinephrin) from medulla of adrenal gland.

* Disorder of heart

(1) High blood pressure/hypertension

- Blood pressure ÷ pressure exerted by ~~wall~~ blood on walls of vessels

unit: mm/Hg

Sphygmomanometer (instrument)

- Normal blood pressure ÷ 120/80

120 is systolic pressure or pumping pressure and 80 is diastolic pressure.

- On repeated check up if blood pressure is equal or more than 140/90, then the condition is known as hypertension/high blood pressure.

(2) CAD (coronary artery disease) / Atherosclerosis^{sis}

- affects coronary artery
- deposition of Ca^{2+} , fibrous tissue, cholesterol, fat etc on wall of coronary vessel.
- Lumen of artery decreases, that affects supply of blood to heart.

(3) Angina / Angina pectoris

- Acute chest pain
- due to less O_2 in part of heart
- ~~seen~~ seen in men and women both
- mostly seen in middle age/elder

(4) Heart failure / congestive heart failure

- Heart is not pumping blood effectively
- Congestion of lungs is seen in this.

(5) Heart attack / Myocardial infarction

- part of heart is dead due to insufficient supply of blood.

(6) Cardiac arrest

- Heart stop pumping blood
- Zero cardiac output =